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(71) Applicant (*for all designated States except US*): BOLTON INSTITUTE OF HIGHER EDUCATION [GB/GB]; Deane Road, Bolton, Lancashire BL3 5AB (GB).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): SMITH, Duncan, Hamilton [GB/GB]; 22 Langley Road, Sale, Cheshire M33 5AY (GB). CONVEY, Harold, James [GB/GB]; 1 North Rise, Greenfield, Oldham, Lancashire OL3 7ED (GB). YATES, Stephen, William [GB/GB]; 11 Oakdale, Harwood, Bolton BL2 3JX (GB). PURDY, John, Harry [GB/GB]; 67 Buncer Lane, Blackburn, Lancashire BB2 6SN (GB). DODDS, Dennis [GB/GB]; 10 Spring Gardens, Harwood, Bolton, Lancashire BL2 3LU (GB).

(74) Agent: GRAVES, Ronald; 13 Queen Victoria Street, Macclesfield, Cheshire SK11 6LP (GB).

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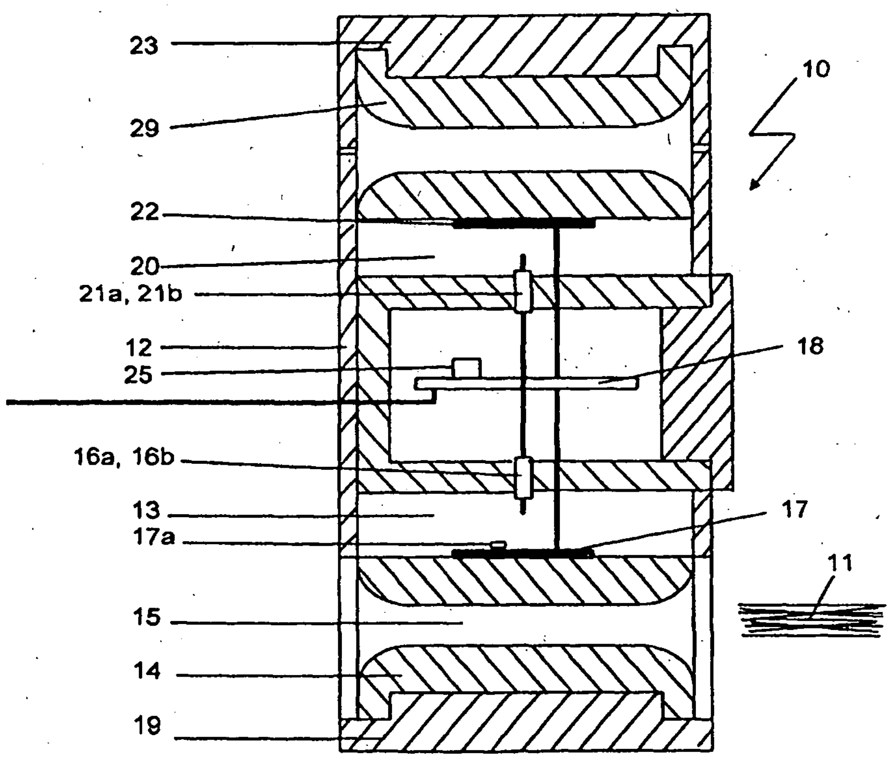
(57) Abstract

An instrument (10) is provided for the measurement of the mass of a fibrous material (11) for the correct control of production processes of fibrous materials such as textiles, wood, tobacco and paper so as to reduce unacceptable products and waste. The instrument (10) has a measuring chamber (13) with a passage (15) through which the material (11) passes. A transmitting aerial (16a) is disposed at one side of the measuring chamber (13) to transmit a measuring electromagnetic signal into the measuring chamber (13), and an operating waveguide plate (17) is disposed between the transmitting aerial (16a) and the passage (15). A ground plate (19) is disposed at the opposite side of the measuring chamber (13) so that an operating electromagnetic wave resonates within the measuring chamber (13), and a receiving aerial (16b) is disposed in the measuring chamber (13) to receive the resonating signal in the measuring chamber (13). The receiving aerial (16b) is operable to detect the frequency of the resonating electromagnetic wave which is used to determine the mass of the material (11).



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MEASURING INSTRUMENT

This invention relates to measuring instruments, and in particular to instruments for the measurement of the mass of a fibrous material. Such measurements are required for the correct control of production processes of fibrous materials such as textiles, wood, tobacco and paper so as to reduce unacceptable products and waste.

There are many types of instrument currently used for measuring the mass per unit length of fibrous material. Such instruments include weighing, mechanical, optical, capacitive, nucleonic and radio frequency (RF) wave instruments, but all of these known instruments have their own drawbacks. Weighing transducers fitted to a conveyor have low accuracy and restricted dynamic range. Mechanical instruments, such as those in which the material is passed between a tongued roller and a grooved roller which separate against a resistance by an amount dependent on the mass of material passing between them, compress the material, and have to be manufactured to a high degree of precision so as to eliminate eccentricity effects. Such instruments are therefore invasive as well as costly. Optical instruments, measuring the amount of light absorbed by the material, are unsuitable for materials of low transparency or high mass and involve complex optics and mechanics resulting in such instruments being costly. In addition ambient light affects their accuracy. Capacitive instruments are extremely sensitive to ambient temperature and moisture, as well as the shape and ionic content of the material being measured. They can also suffer from d.c. conductivity effects. Nucleonic instruments are not favoured due to the inherent radiation risks involved. The known RF instruments measure the loss of signal as the material passes between a transmitting and a receiving aerial, the loss being proportional to the mass of that material. This technique is also used for the measurement of the moisture content of the material, for example as described in US Patent No. 5621330. However, in that case the instrument described is used to measure the moisture content of a bale of material, and the readings and the subsequent calculations take several seconds. Therefore readings are obtained at discrete spaced points of the moving material, and such an instrument is not suitable for performing a substantially continuous determination of the mass per unit length a travelling fibrous material, particularly at speeds of up to 1000 metres/min currently achieved in the textile industry. In addition such an instrument is susceptible to drift over a period of time and the measurement scale is non-linear. In consequence there are calibration difficulties with this instrument.

It is an object of the present invention to provide an instrument for the measurement of the mass of a fibrous material which is suitable for continuous production control at currently

achieved speeds, is non-invasive and overcomes the various disadvantages of the above described known instruments.

The invention provides an instrument for the measurement of the mass of a fibrous material, comprising a measuring chamber having a passage through which the material may pass, a transmitting aerial disposed at one side of the measuring chamber to transmit a measuring electromagnetic signal into the measuring chamber, an operating waveguide plate disposed between the transmitting aerial and the passage, a ground plate disposed at the opposed side of the measuring chamber whereby an operating electromagnetic wave resonates within the measuring chamber, and a receiving aerial disposed in the measuring chamber to receive the resonating signal in the measuring chamber and operable to detect the frequency of the resonating electromagnetic wave.

The receiving aerial may be disposed to the one side of the measuring chamber, and the transmitting aerial and the receiving aerial may be disposed laterally of each other relative to the direction of fibrous material flow.

The instrument may have a control unit operable to receive a signal from the receiving aerial and to measure the change in frequency of the resonating wave due to the presence of the material in the passage. The control unit may be programmable, and may be programmed to calculate the mass of the material from the measured change in frequency.

The ground plate may comprise a second waveguide plate between which waveguide plates the electromagnetic wave resonates. The opposed waveguide plates may be substantially H-shaped in planform. In this case the transmitting aerial may be offset from the centre of the measuring chamber in the direction opposed to that of fibrous material flow, and the receiving aerial may be offset from the centre of the measuring chamber in the direction of fibrous material flow. The receiving aerial may be disposed to the opposed side of the measuring chamber.

The invention also provides an instrument for the measurement of the mass of a fibrous material, comprising a measuring chamber having a passage through which the material may pass, transmitting means operable to transmit a measuring electromagnetic signal into the measuring chamber and the material passing therethrough, a receiving means operable to detect the measuring signal, a reference chamber, reference transmitting means operable to transmit a reference electromagnetic signal into the reference chamber, a reference receiving

means operable to detect the reference signal, and a control unit operable to receive signals from the measuring and reference receiving means.

A respective waveguide plate may be disposed in the measuring and reference chambers and a respective ground plate may be disposed at the opposed side of the measuring and reference chambers, whereby respectively an operating and a reference electromagnetic wave resonates within the measuring and reference chambers, and the respective receiving means disposed within the measuring and reference chambers may be operable to detect the frequency of the resonating measuring and reference electromagnetic waves. The control unit may be programmable and programmed to calculate the mass of the material in the measuring chamber from the difference in frequencies of the resonating operating and reference signals. The instrument may comprise switching means operable between a first condition in which the control unit receives the signal from the measuring receiving means and a second condition in which the control unit receives the signal from the reference receiving means. The control unit may comprise timing means operable to change the switching means between the first condition and the second condition at predetermined time intervals.

The control unit may be adjustable for differing fibrous materials. The control unit may have an indicator operable to indicate whether the mass of the material is above or below a predetermined value. The indicator may comprise a plurality of diodes. A centrally disposed diode may be of one colour and the other diodes may be of another colour. The one colour may be green and the other colour may be red. The other diodes may be disposed above and below the central diode. The control unit may also have an output operable to download information to a personal computer and to provide a signal proportional to the mass measurement of the fibrous material. The signal may be in the range 0 to 10 volts.

The instrument may comprise a RF generating device operable to generate an electromagnetic signal of RF frequency. The electromagnetic signal may have a frequency of between 400 MHz and 4 Ghz. The RF generating device may be disposed between the measuring chamber and the reference chamber.

The instrument may be disposed to receive material from a drawframe. In this case the instrument may comprise two measuring chambers as aforesaid. The measuring chambers may be disposed side-by-side. The instrument may also comprise two reference chambers, and the two reference chambers may be disposed side-by-side. The RF generating device may be disposed between the two reference chambers and the two measuring chambers.

The measuring chamber; or the measuring chamber and reference chamber; or the two measuring chambers and the two reference chambers; may be mounted in an enclosure. The enclosure may be of aluminium. The passage may be of a plastics material.

The invention will now be further described with reference to the accompanying drawings in which:

Fig. 1A is a sectional side elevation of one embodiment,
Fig. 1B is a perspective cut-away view of the first embodiment,
Fig. 2A is a sectional side elevation of a second embodiment,
Fig. 2B is a perspective cut-away view of the measurement chamber of the second embodiment,
Fig. 3 is a perspective cut-away view of a third embodiment, and
Fig. 4 is a view of the control unit and connection details.

Referring now to Figs. 1A and 1B, there is shown an instrument 10 for the measurement of the mass of a fibrous material 11 as it passes through the measuring instrument 10. The instrument 10 has an enclosure 12 of aluminium or other suitable metallic material which provides a measuring chamber 13. The fibrous material 11 is guided through the measuring chamber 13 by a trumpet shaped guide 14 formed of a plastics material or other suitable electrically non-conductive material having a passage 15 therethrough for the fibrous material 11. Mounted in the enclosure 12 above the chamber 13 are a transmitter aerial 16a and a receiver aerial 16b, and within the chamber 13 beneath the aerials 16a and 16b and secured to the upper surface of the trumpet guide 14 is a waveguide plate in the form of a strip 17.

An electromagnetic signal of radio frequency is generated by a generating device 18 and is transmitted through the aerial 16a. The generated RF signal has a frequency of between 400 MHz and 4 Ghz, which enables the instrument 10 to be relatively small. Transmission of this signal causes an electromagnetic wave to resonate in the chamber 13, including the passage 15, between the waveguide strip 17 and a ground plate 19 formed by the base of the enclosure 12. The enclosure 12 reduces loss of the resonating wave to atmosphere, and all access covers to the enclosure 12 are provided with labyrinth seals to reduce such loss. The dimensions of the enclosure 12 are chosen to ensure that any resonance of the enclosure itself will not interfere with the measurement. When the fibrous material 11 is passed through the passage 15, the frequency of resonance of the wave in the chamber 13 is different from that when no fibrous material 11 is present, corresponding with the variation of sound frequency with the amount of liquid in a sound tube. The amount of this change in frequency is dependent on the mass per unit length of the fibrous material 11. the oscillation frequency

decreasing with an increase of the amount of fibrous material 11 within the chamber 13. This change of frequency is detected by the receiving aerial 16b and conveyed via the RF generating device 18 to a control unit 41 shown in Fig. 4. The RF generating device 18 is adjusted externally by the control unit 41 initially to give readings appropriate to the type of fibrous material 11 to be monitored. The control unit 41 is programmed to calculate the mass per unit length of the fibrous material 11 from the difference between the signals received from the waveguide strip 17 and from the receiving aerial 16b via the RF generating device 18. An indicator 26 is mounted on the front of the control unit 41 , see FIG. 4, to indicate whether the mass per unit length of the fibrous material 11 is equal to a predetermined value. If the mass is equal to the predetermined value, a green LED 27 disposed centrally of the indicator 26 is illuminated, but if the mass is above or below that predetermined value, an appropriate one of the red LEDs 28 disposed above or below the central LED 27 will be illuminated. Such mass determinations can be made every few milli-seconds, and therefore even with current textile sliver speeds in excess of 1000 metres/min, the instrument is capable of substantially continuously monitoring the mass per unit length of the fibrous material 11. The control unit 41 can also provide an output signal which is directly proportional to the mass determination made every few milli-seconds. Therefore, even at material speeds in excess of 1000 metres/min, this capability can be used to alter the parameters of the process continually producing the fibrous material 11 to rectify any discrepancy from the desired value of mass per unit length, so that a substantially constant desired value is obtained.

In a simple arrangement, the abovementioned calculation can be made from the difference in signals generated by the RF generating device 18, transmitted by the aerial 16a and received by the aerial 16b and the waveguide strip 17, when fibrous material 11 is present and when it is not present. However such calculations are prone to error from changes over time in ambient conditions and electronic drift in the voltage control oscillator (V.C.O.). To overcome this problem, a reference chamber 20 is provided in the enclosure 12. The reference chamber 20 has a respective reference transmitter aerial 21a and receiver aerial 21b, reference waveguide strip 22 and reference earth plate 23, but a guide 29 being almost closed at its ends provides that there is no passage for fibrous material. A timing device 24, which is incorporated in the control unit 41, causes a switching device 25, mounted on the RF generating device 18, to change at predetermined time intervals between a first condition in which the RF generating device 18 receives the signal from the measuring waveguide strip 17 and a second condition in which the RF generating device 18 receives the signal from the reference waveguide strip 22. A pin diode 17a on the waveguide strip 17 alters the wavelength of the and effectively alters the operational frequency of the waveguide strip 17 out of the range of the V.C.O., simultaneously biasing the reference chamber 20 through aerials 21a and 21b. When a

forward bias potential is applied to the pin diode 17a, charge carriers are injected into the Intrinsic (I) region from both N and P regions. However, the lightly doped design of the I region is such that the N and P type charge carriers do not immediately re-combine, as in the normal p.n. junction diodes. Hence, when the pin diode 17a is forward biased, the pin diode 17a has no effect on the frequency response of the measuring chamber 13, but when the biasing to the pin diode 17a is switched off, the frequency response of the measuring chamber 13 is altered by approximately 10%, taking it out of the range of the V.C.O., creating the effect that the measuring chamber 13 is switched off. In the first condition, a pin diode 22a on the reference waveguide 22 is caused to resonate at a frequency outside the range of the instrument 10, thus effectively reference chamber 20 being switched 'off'. In the second condition, the pin diode 17a on the measuring waveguide strip 17 is caused to resonate at a frequency outside the range of the instrument 10 so that in turn the measuring chamber 13 is switched 'off'. Since the reference chamber 20 is subject to ambient conditions prevailing at any particular time, any change in those ambient conditions over time will be reflected in the signal received by the receiving aerial 21b from the reference waveguide strip 22, and periodic switching to the second condition will 'update' the no-material signal value. The control unit 41 compares the latest signal sent to it from the reference waveguide strip 22 with the stored reference value to correct any drift and calculate the current mass per unit length of the fibrous material 11 in the passage 15.

In Figs. 2A and 2B there is shown a second embodiment, namely an instrument 30 having an aluminium enclosure 31 in which there is a measuring chamber 32 with a passage 33 provided therethrough by a plastics material guide 34. Disposed just above the passage 33 is a H or butterfly-shaped waveguide plate 35 and disposed just below the passage 33 is a second H or butterfly-shaped waveguide plate 37. Extending downwardly into the chamber 32 is a transmitter aerial 36a which is offset from the centre of the measuring chamber 32 in the direction opposed to that of fibrous material 11 flow, and extending upwardly into the chamber 32 is a receiver aerial 36b which is offset from the centre of the measuring chamber 32 in the direction of fibrous material 11 flow. It has been found that this configuration gives a better reflected signal response for wider widths of fibrous material 11. In consequence a more accurate and representative figure for the average mass per unit length across the width of the fibrous material 11 is obtained. A correspondingly configured reference chamber 38 is disposed above the measuring chamber 32 and the RF generating device 18. This configuration of measuring chamber 32 can be incorporated as the measuring chamber 13 of the embodiment 10 of Figs. 1A and 1B, and also as the reference chamber 20 of that embodiment if desired.

In Fig. 3 there is shown a third embodiment of instrument 40 having an enclosure 42 in which a plastics material trumpet guide 43 is divided into two passageways 15a and 15b, of the type shown in the previous Figs., within the measuring chamber 13. In the case of use of the instrument with a textile Drawframe, it has been found that combining all of the slivers from the drawframe into one sliver to pass through the instrument leads to results which may not be sufficiently accurate. To overcome this problem the slivers issuing from the drawframe are divided into two streams of slivers 11a, 11b and these two streams 11a, 11b are passed through the passageways 15a and 15b as shown in Fig. 3. This arrangement places each stream 11a, 11b in the most sensitive area of the RF signals transmitted through the transmitter aerial 16a and received by the receiving aerial 16b. The passages 15a and 15b are disposed side-by-side and in this case the reference chamber 20 has similarly disposed side-by-side guides 29 above the measuring chamber 13 in the single enclosure 42. The RF generating device 18 is mounted in the enclosure 42 between the measuring chamber 13 and the reference chamber 20, and the indicator 26 is mounted on the front of the control unit 41.

In Fig. 4 there is shown the arrangement of the instrument 10, 30 or 40 in relation to the control unit 41 and a power supply 44. The indicator 26 is disposed on the front of the control unit 41, with the red LEDs 28 disposed above and below the central green LED 27. The calculated mass per unit length is shown as a digital display 45, and further displays 46 indicate the pre-set values of the various parameters relating to the fibrous material being monitored.

The instruments 10, 30 and 40 may be used to test any fibrous material such as textile material, wood, paper, tobacco and the like, and may be used in conjunction with any fibrous material processing machine. By means of the invention an accurate and relatively inexpensive instrument is provided for the measurement of the mass of a fibrous material, which avoids the disadvantages of the known instruments. The instrument is capable of monitoring the fibrous material substantially constantly and therefore can be readily used in a feedback loop to control the processing of the fibrous material, for example as a Drawframe or Carding machine autoleveller. For very wide webs of fibrous material, more than two passages 15 may be provided side-by side across the width of the material if desired, with or without an enclosure for all of the passages 15. In addition, the problem of drift of the instrument due to changes in ambient conditions over a period of time can be avoided in a simple and inexpensive manner. By use of radio frequency signals in the range above 400 MHz, the instrument may be smaller than known instruments using radio frequencies in lower ranges. There are no moving parts, leading to low maintenance costs, and production tolerances are not as critical as with some known instruments, thereby reducing the cost of manufacture.

WHAT WE CLAIM IS

1. An instrument for the measurement of the mass of a fibrous material, comprising a measuring chamber having a passage through which the material may pass, a transmitting aerial disposed at one side of the measuring chamber to transmit a measuring electromagnetic signal into the measuring chamber, an operating waveguide plate disposed between the transmitting aerial and the passage, a ground plate disposed at the opposed side of the measuring chamber whereby an operating electromagnetic wave resonates within the measuring chamber, and a receiving aerial disposed in the measuring chamber to receive the resonating signal in the measuring chamber and operable to detect the frequency of the resonating electromagnetic wave.

2. An instrument according to claim 1, wherein the receiving aerial is disposed to the one side of the measuring chamber.

3. An instrument according to claim 2, wherein the transmitting aerial and the receiving aerial are disposed laterally of each other relative to the direction of fibrous material flow.

4. An instrument according to any one of claims 1 to 3, comprising a control unit operable to receive a signal from the receiving aerial and to measure the change in frequency of the resonating wave due to the presence of the material in the passage.

5. An instrument according to claim 4, wherein the control unit is programmable.

6. An instrument according to claim 5, wherein the control unit is programmed to calculate the mass of the material from the measured change in frequency.

7. An instrument according to any one of claims 1 to 6, wherein the ground plate comprises a second waveguide plate between which waveguide plates the electromagnetic wave resonates.

8. An instrument according to claim 7, wherein the opposed waveguide plates are substantially H-shaped in planform.

9. An instrument according to claim 8, wherein the transmitting aerial is offset from the centre of the measuring chamber in the direction opposed to that of fibrous material flow, and

the receiving aerial is offset from the centre of the measuring chamber in the direction of fibrous material flow.

10. An instrument according to claim 9, wherein the receiving aerial is disposed to the opposed side of the measuring chamber.

11. An instrument for the measurement of the mass of a fibrous material, comprising a measuring chamber having a passage through which the material may pass, transmitting means operable to transmit a measuring electromagnetic signal into the measuring chamber and the material passing therethrough, a receiving means operable to detect the measuring signal, a reference chamber, reference transmitting means operable to transmit a reference electromagnetic signal into the reference chamber, a reference receiving means operable to detect the reference signal, and a control unit operable to receive signals from the measuring and reference receiving means.

12. An instrument according to claim 11, wherein a respective waveguide plate is disposed in the measuring and reference chambers and a respective ground plate is disposed at the opposed side of the measuring and reference chambers, whereby respectively an operating and a reference electromagnetic wave resonates within the measuring and reference chambers.

13. An instrument according to claim 12, wherein the respective receiving means disposed within the measuring and reference chambers are operable to detect the frequency of the resonating measuring and reference electromagnetic waves.

14. An instrument according to claim 13, wherein the control unit is programmable.

15. An instrument according to claim 14, wherein the control unit is programmed to calculate the mass of the material in the measuring chamber from the difference in frequencies of the resonating operating and reference signals.

16. An instrument according to claim 15, comprising switching means operable between a first condition in which the control unit receives the signal from the measuring receiving means and a second condition in which the control unit receives the signal from the reference receiving means.

17. An instrument according to claim 16, wherein the control unit comprises timing means operable to change the switching means between the first condition and the second condition at predetermined time intervals.

18. An instrument according to any one of claims 11 to 17, wherein the control unit is adjustable for differing fibrous materials.

19. An instrument according to any one of claims 11 to 18, wherein the control unit has an indicator operable to indicate whether the mass of the material is above or below a predetermined value.

20. An instrument according to claim 19, wherein the indicator comprises a plurality of diodes.

21. An instrument according to claim 20, wherein a centrally disposed diode is of one colour and the other diodes are of another colour.

22. An instrument according to claim 21, wherein the one colour is green and the other colour is red.

23. An instrument according to claim 21 or claim 22, wherein the other diodes are disposed above and below the central diode.

24. An instrument according to any one of claims 11 to 23, wherein the control unit has an output operable to download information to a personal computer and to provide a signal proportional to the mass measurement of the fibrous material.

25. An instrument according to claim 24, wherein the signal is in the range 0 to 10 volts.

26. An instrument according to any one of claims 1 to 25, comprising a RF generating device operable to generate an electromagnetic signal of RF frequency.

27. An instrument according to claim 26, wherein the electromagnetic signal has a frequency of between 400 MHz and 4 Ghz.

28. An instrument according to claim 26 or claim 27, wherein the RF generating device is disposed between the measuring chamber and the reference chamber..

29. An instrument according to any one of claims 1 to 28, disposed to receive material from a textile Drawframe.

30. An instrument according to claim 29, comprising two measuring chambers.

31. An instrument according to claim 30, wherein the measuring chambers are disposed side-by-side.

32. An instrument according to claim 31, also comprising two reference chambers.

33. An instrument according to claim 32, wherein the two reference chambers are disposed side-by-side.

34. An instrument according to claim 33 when dependent on claim 26, wherein the RF generating device is disposed between the two reference chambers and the two measuring chambers.

35. An instrument according to any one of claims 1 to 10, wherein the measuring chamber is mounted in an enclosure.

36. An instrument according to any one of claims 11 to 28, wherein the measuring chamber and reference chamber are mounted in an enclosure.

37. An instrument according to any one of claims 29 to 36, wherein the two measuring chambers and the two reference chambers are mounted in an enclosure.

38. An instrument according to any one of claims 35 to 37, wherein the enclosure is of aluminium.

39. An instrument according to any one of claims 1 to 38, wherein the passage is of a plastics material.

40. An instrument for the measurement of the mass of a fibrous material substantially as hereinbefore described with reference to and as illustrated in Figs. 1A, !B and 4. or Figs. 2A, 2B and 4 or Figs. 3 and 4 of the accompanying drawings.

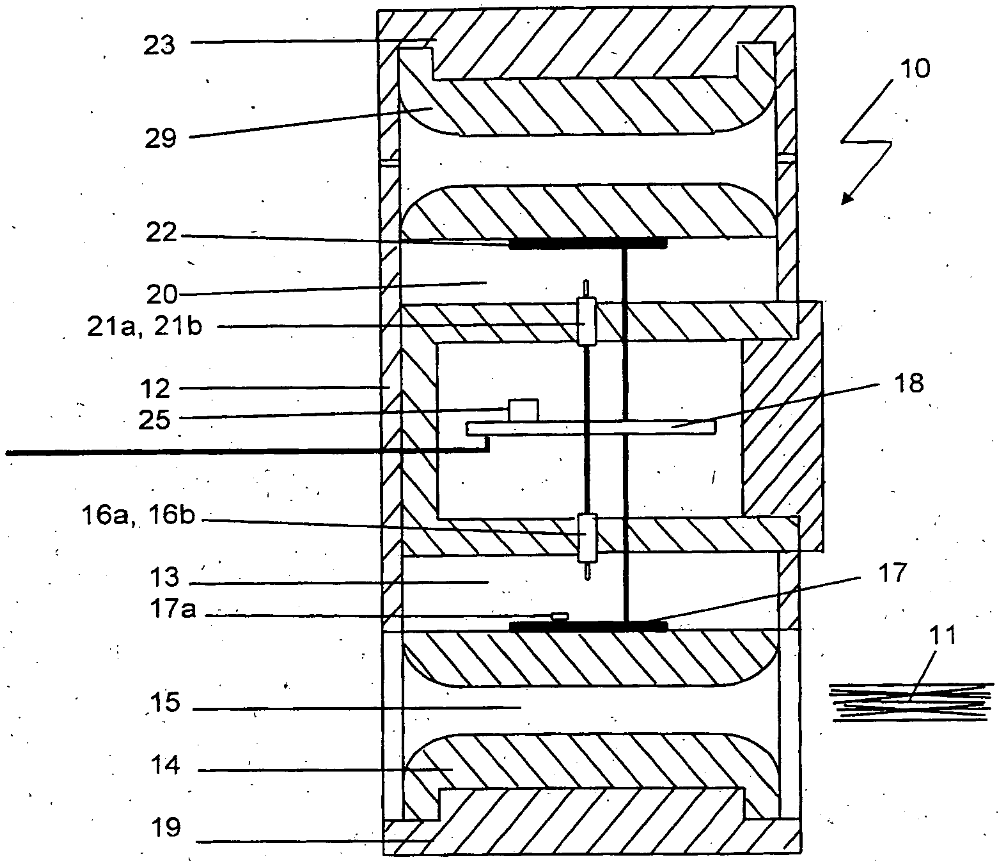
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Fig. 1A

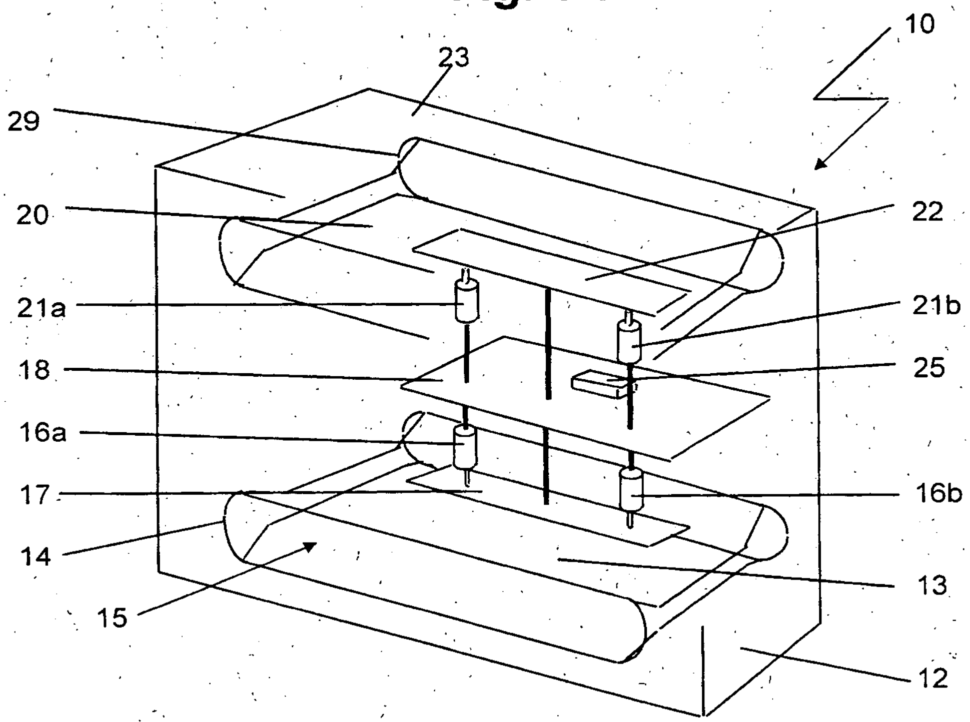
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Fig. 1B

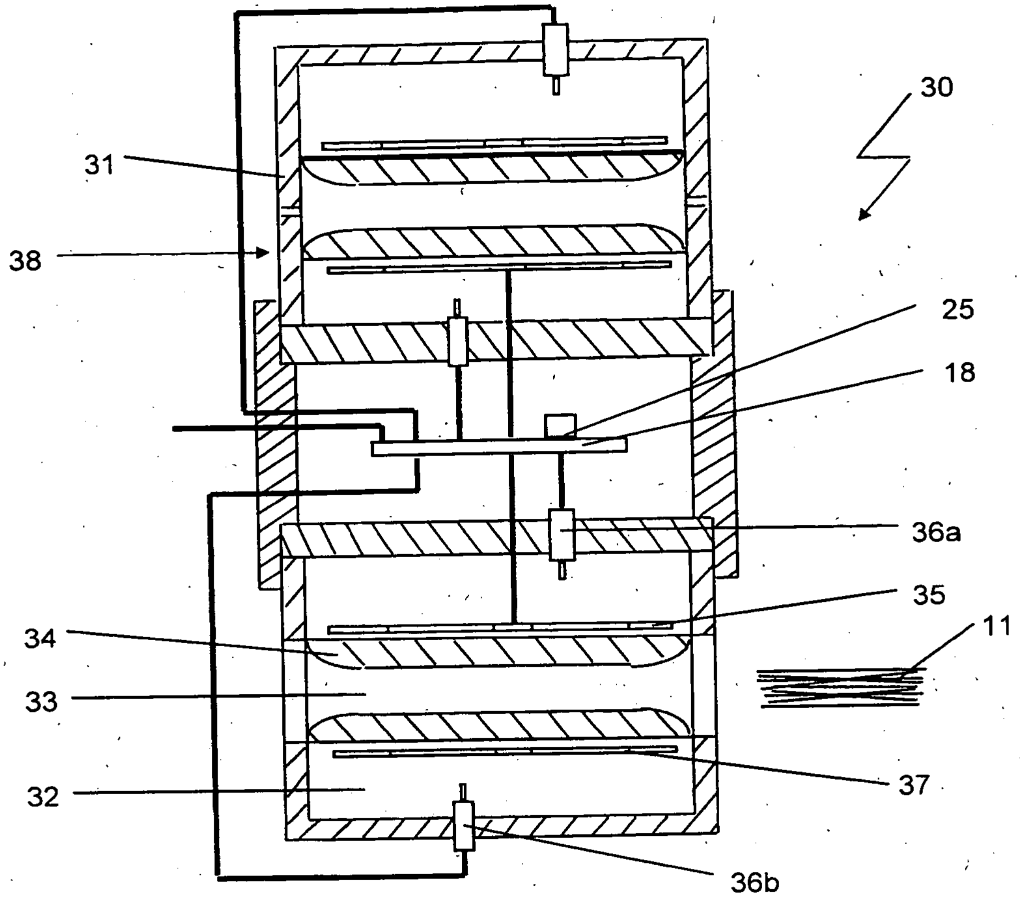

Fig. 2A

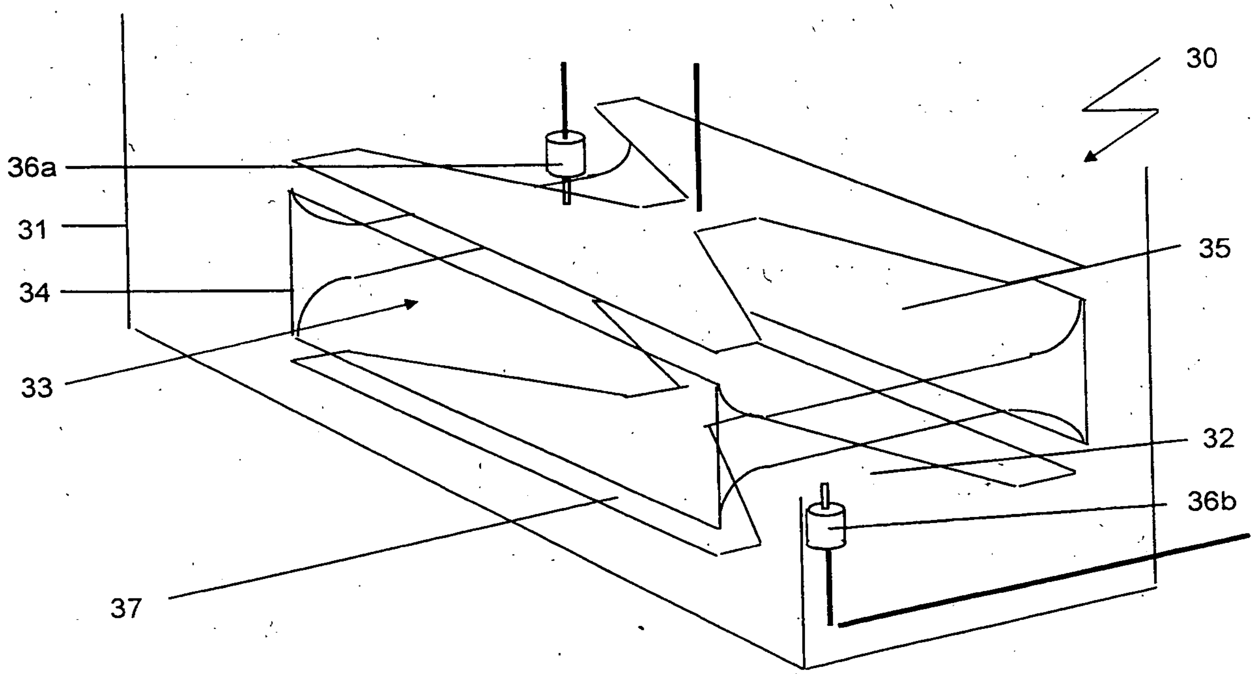

Fig. 2B

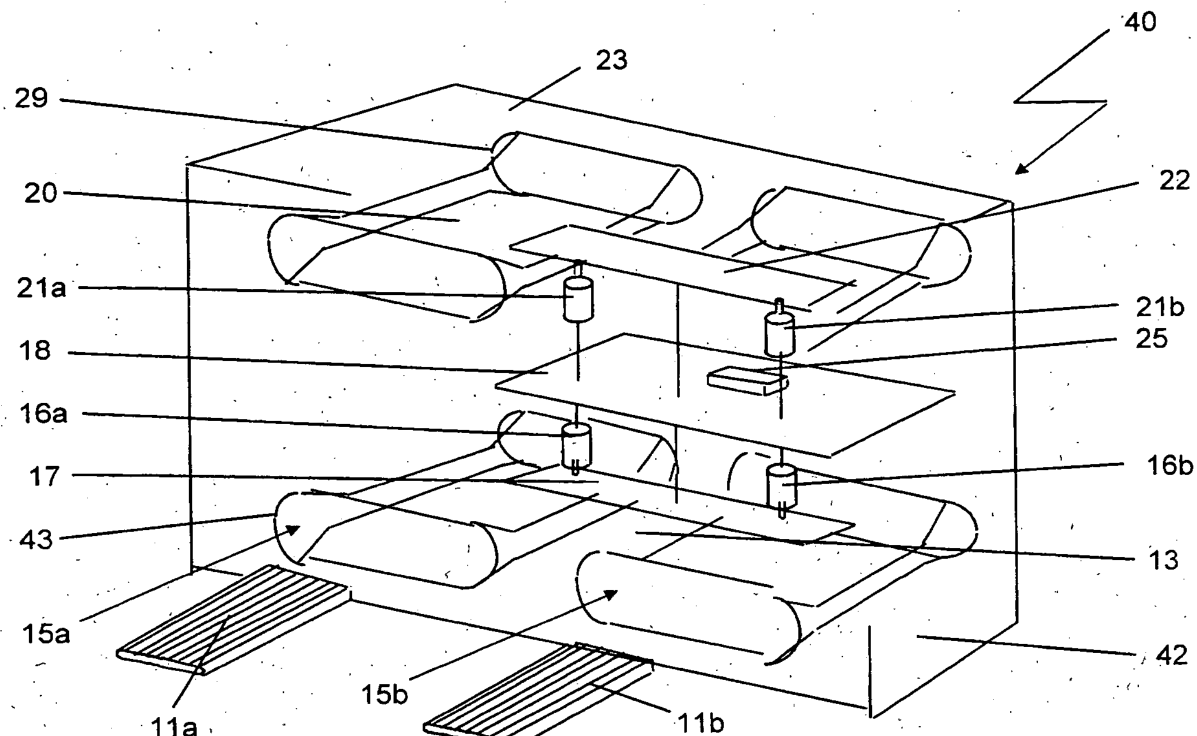
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Fig. 3

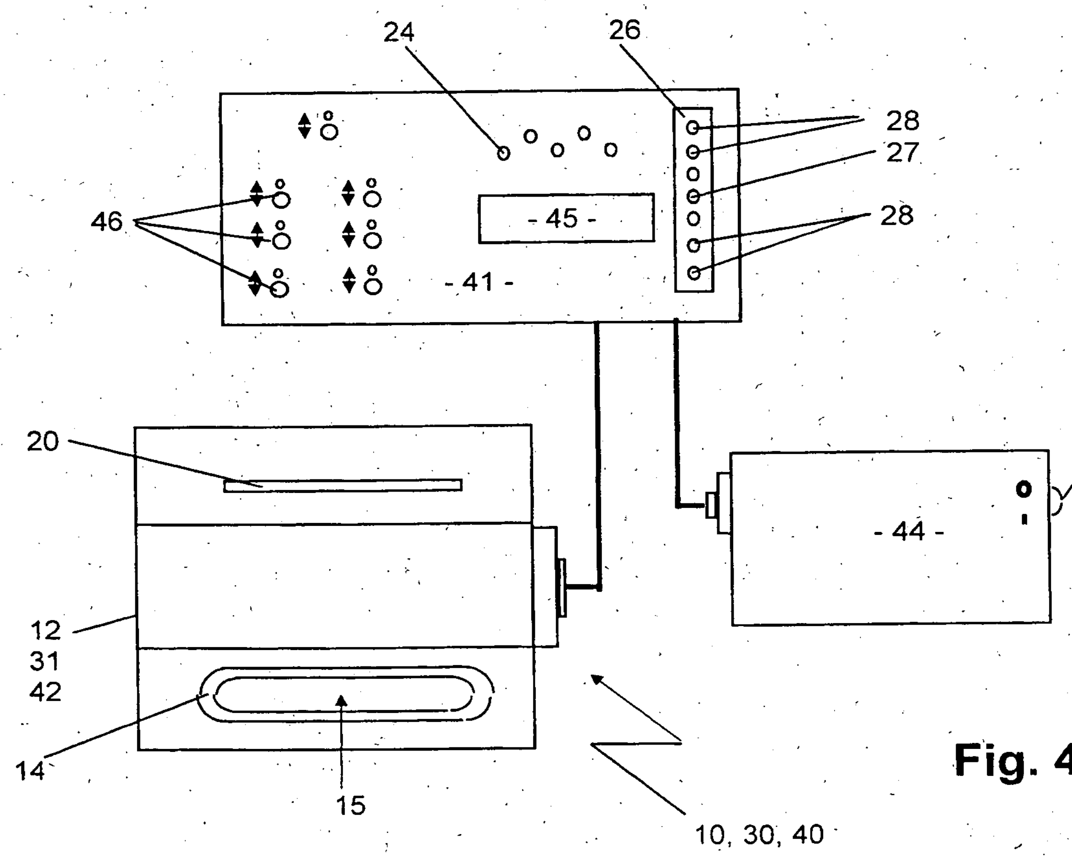
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Fig. 4